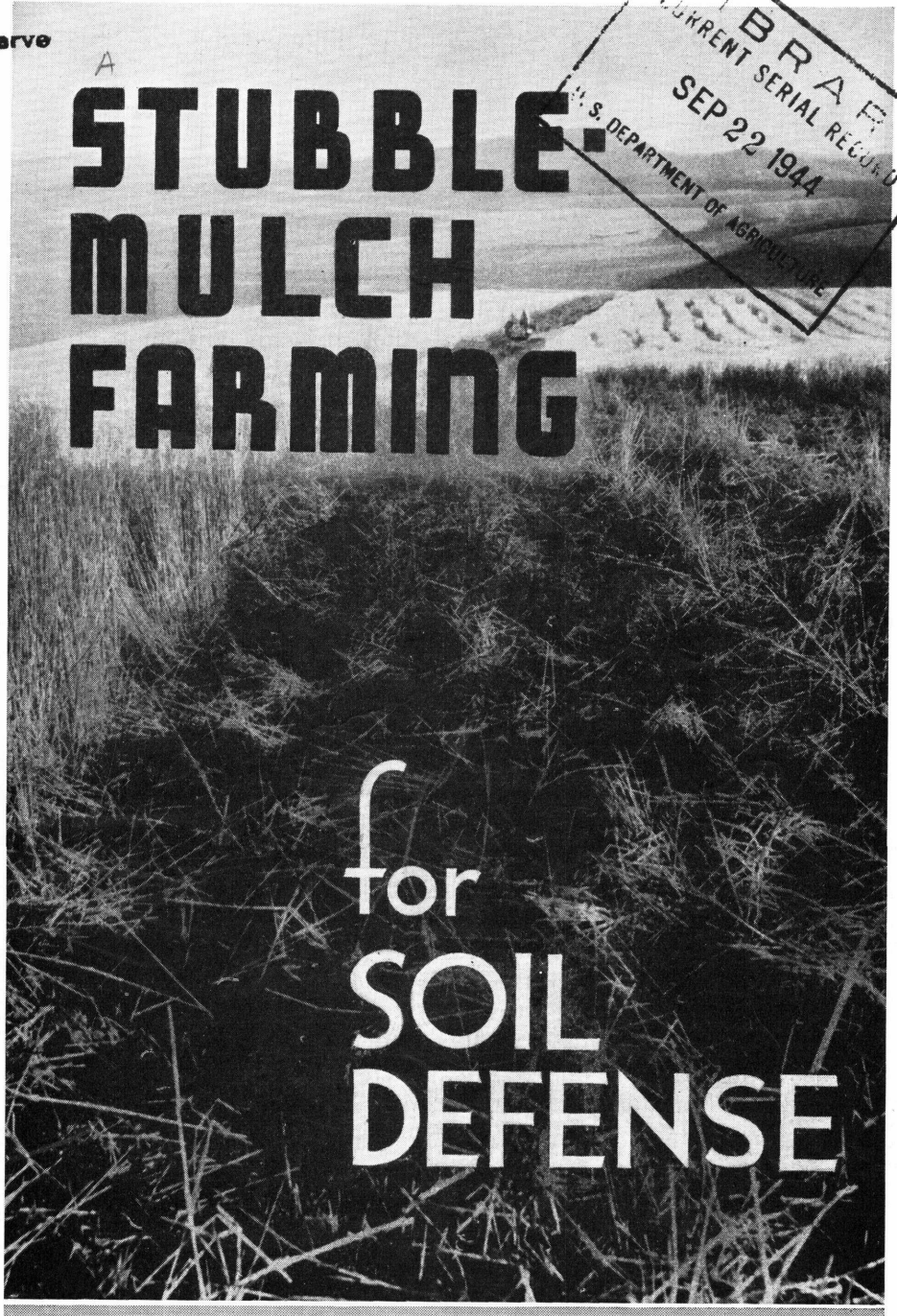
A STUBBLE-MULCH FARMING for SOIL DEFENSE



FARMERS' BULLETIN No. 1917
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STUBBLE-MULCH farming, spectacular in its recent spread across the West, has sound scientific support. In one form or another, it has been demonstrating its advantages on experimental plots and in isolated field trials for many years. It is a practice that furthers the highest crop and livestock production compatible with the principle of soil security. It is a simple but effective method that will help us to avoid in the present emergency the disastrous aftermaths of the plow-up program of the 1920's.

Materials for mulching are at hand—products of the land itself—waiting to be used for the retention of crop-making moisture and soil.

Equipment can be bought on the market, or it can be rigged up by the farmer himself.

Stubble-mulch farming can be fitted into a general conservation system—applied to grain fields, row-crop land, and strip-cropped areas. It is flexible and economical, requires less mule power or machine power.

Success with this system is as much a matter of correct timing as of anything else. Mulching operations should be gaged to beat the weeds to the field immediately after harvest, before they have a chance to make off with the moisture. It is also as important to operate at correct speed as it is to use the right equipment. Finally, mulching should be accepted as but one of the practices that make up a conservation-farming program.

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STUBBLE-MULCH FARMING FOR SOIL DEFENSE

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Contents

	Page
Mulch material grown on land to be mulched	1
Important operations in mulch farming	3
In the Great Plains	5
Annual cropping	5
Summer fallow	5
In the wheat-growing areas west of the Rockies	6
Summer fallow	8
Annual cropping	8
In the South and East	10
Cover crops as mulch	10
Row crop and legume rotations	11
Tillage implements	14
Modified moldboard plows	14
Duckfoot shovels or sweeps	16
Rotary rod weeders	16
Straight-blade cultivators	17
Disks	19
Subsoilers	19
Grain drills	21
Row-crop planters	22

MULCH MATERIAL GROWN ON LAND TO BE MULCHED

FARMERS who can adopt it will naturally want to know about a tillage practice that lets more water into the soil, reduces evaporation, prevents soil from blowing or washing away, keeps down weeds, improves soil structure, and kills grasshopper eggs.

These results are obtained from the practice of using as a mulch on cultivated fields the residues or top growth of crops grown on these fields. This can be done by tilling the soil with implements that leave these materials on the surface.

Extensive areas in some Western States are now under this type of cultivation. In one State the practice of using crop residues as a stubble mulch on grain fields had its beginning as far back as 1910 or before, when somebody began "gopher plowing" summer-fallowed land. In another State by 1941 most of the 90,000 or more acres of cropland that were protected by a stubble mulch were brought under this type of management.

For the farmer who began stubble-mulch tillage in 1941, special equipment or attachments for the ordinary farm implements had been developed. Back in 1910 "gopher plowing" was done by removing the moldboard from the plow before putting it into the field.

In whatever way this new tillage may have been begun in a locality, whether on the farm or at an experiment station, it has replaced the old way of plowing wherever given extensive trial. Covering crop residues several inches below a surface of bare soil is being replaced by the newer practice of leaving the residues on top. Mixing organic material with the soil has also proved to be less effective than leaving it on top. (See fig. 1.)

In the Great Plains, bare-cultivated fields are likely to be a wind-erosion hazard except in years of exceptionally heavy rainfall. But if rough-cultivated and protected by a mulch, the fields lose little soil by wind erosion, and after a number of years the structure of the

soil is in better condition for crop growth. Similarly, farther west, where winter rainfall damages bare-cultivated fields, a mulch on the surface, supplemented by special tillage if needed, keeps the ground open so that less rainfall is lost in runoff. The soil loss, too, is less, and the structure of the soil improves.

Using a mulch to get more moisture into the ground, to improve the soil structure, and to reduce soil loss by wind and water erosion—this is soil management for sustained yields.

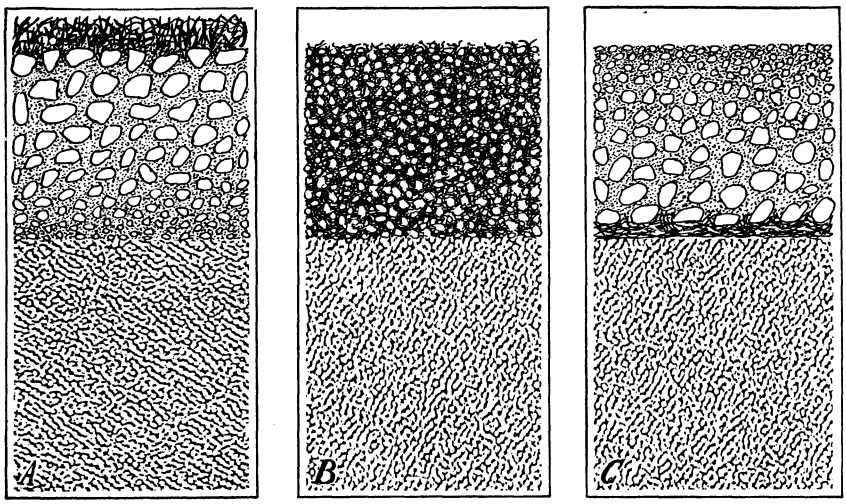


FIGURE 1.—Organic materials partially mixed with the surface soil (*B*) provide greater protection against erosion than they would if completely covered (*C*) but not so much as if left on top (*A*).

Experiments and experience have shown that mulching with crops grown on the land works in with conservation practices—strip cropping, terracing, and the use of rotations and cover crops. This kind of mulching can be done in grain fields and fields planted to row crops, in orchards, and in vineyards.

The spread of this practice to all areas where it can be used successfully requires that tillage methods be adapted to a wide variety of soil and climatic conditions and to many different crops. Suitable tillage equipment must be used. Farmers can supply themselves with much of this equipment by changing somewhat the machinery they already have. Modified moldboard plows have been widely used. Taking the moldboard off the plow is not all that is needed to adjust farm machinery to this new tillage, but it is still a good way of using one machine for certain jobs. Some farmers have one type of equipment, some another. This bulletin does not suggest a choice, but gives a brief description of representative types of equipment used in mulching extensive areas.

The tillage practices described are chiefly those that have proved successful in grain fields in the Pacific Northwest and on the Great Plains. Some additional suggestions are made about mulching with cover crops or with residues from small grains, legumes, and row crops—practices of particular interest in the East and South.

IMPORTANT OPERATIONS IN MULCH FARMING

Certain tillage practices are common to mulching with materials grown on the land to be mulched, whether the crop is a legume, a small grain, corn, cotton, or sorghum, whether it is grown in areas of summer or winter rainfall, or in a summer-fallow or an annual-cropping system of farming.

1. Distribute straw by attaching a straw spreader to the combine. This prevents accumulation of the straw in bundles or rows. Chop cornstalks and the stalks of such crops as cotton and sorghum before spreading them over the field.
2. Use tillage implements that leave stubble or other material on top (figs. 2 and 3), unless it is unusually heavy.
3. If the stubble is too heavy to permit cultivation, break it into shorter lengths and partially cover it.
4. If the stubble is too light to provide complete protection, roughen the surface by special tillage practices.
5. Till as soon after harvest as is necessary to kill weeds.
6. Plow to the lowest cultivated depth at the first tillage.
7. After the first tillage use a rod weeder or other available equipment having similar action to compact the soil beneath the surface.
8. Prepare a fine, firm seedbed at the level where seed is to be placed, though the surface may be cloddy.
9. Perform all tillage and seeding operations on the contour.
10. Use stubble mulch in combination with crop rotations, strip cropping, and terracing.
11. Operate machinery at correct speed. High-speed tillage covers too much of the residues and pulverizes the surface soil.

WN-5102

FIGURE 2.—Wheat stubble was left on the surface by tilling with a moldboard plow from which the moldboard had been removed.

OREG-6000

FIGURE 3.—Volunteer rye was taking moisture needed for the next crop. When the rye was 8 inches high the field was cultivated with a straight-blade cultivator to kill the rye and bindweed.

MONT-2737

FIGURE 4.—A grain field after tillage with larger sweeps. The heavy stubble will be broken down and brought in contact with the soil by later cultivation.

IN THE GREAT PLAINS

Wheat is grown in the Great Plains under the summer-fallow system and as an annual crop. In both types of farming the stubble is used as a mulch to conserve moisture and prevent soil blowing. Duckfoot cultivators or sweeps have been more widely used than other implements to produce this mulch (fig. 4).

ANNUAL CROPPING

In areas where a crop is grown every year, tillage operations to prepare the seedbed for fall seeding should begin immediately after harvest. The weeds should be killed with a minimum of disturbance, since rough cultivation will increase evaporation of soil moisture.

On light stubble, operation of the rod weeder is all the cultivation necessary to prepare the seedbed. Winter wheat may be seeded in a bed less firm and fine than spring wheat, but all cultivation between harvest and seeding should leave the soil sufficiently compacted to prevent circulation of air through the soil.

For spring wheat the sequence of tillage operations is determined by moisture conditions. Initial tillage [1] is done in the fall if there is sufficient moisture, and final preparation of the seedbed is postponed until spring. If the season is extremely dry, all tillage may be left until spring.

Plowing and seeding may then be done at the same time. The line of implements drawn in this combined operation usually includes a one-way disk, a packer, and a drill. If it is more desirable to cultivate and seed in separate operations the tillage equipment and the packer are used together, and the seed is planted in another operation. Cultivating and planting in one operation takes less time and puts the seed in the soil with a minimum loss of moisture.

SUMMER FALLOW

In the summer-fallow system the soil is without the protection of a growing crop during the spring and early summer, when erosion is most severe. Furthermore, in these drier, summer-fallow areas there is likely to be too little wheat stubble for a satisfactory mulch, and the summer rains hasten decomposition of what there is. Cultivation in these areas, as distinct from that in others, is therefore characterized by methods that best preserve the stubble and supplement the lack of stubble.

If there is no need for cultivation immediately after harvest to kill weeds, the stubble may be left standing until the spring of the next year. But if there is sufficient moisture for weed growth, cultivation with a rod weeder or suitable sweep equipment must begin immediately. If the soil becomes too compact for cultivation with regular rod weeder, special shovel attachments should be brought into use. (See p. 17.)

[1] Initial tillage includes the operations commonly known as plowing and all other operations carried out to loosen the soil sufficiently to provide proper conditions for the growing of crops.

If there is not enough mulch to give adequate protection against wind erosion in the spring and summer of the fallow year, tillage with implements that leave a cloddy surface will help.

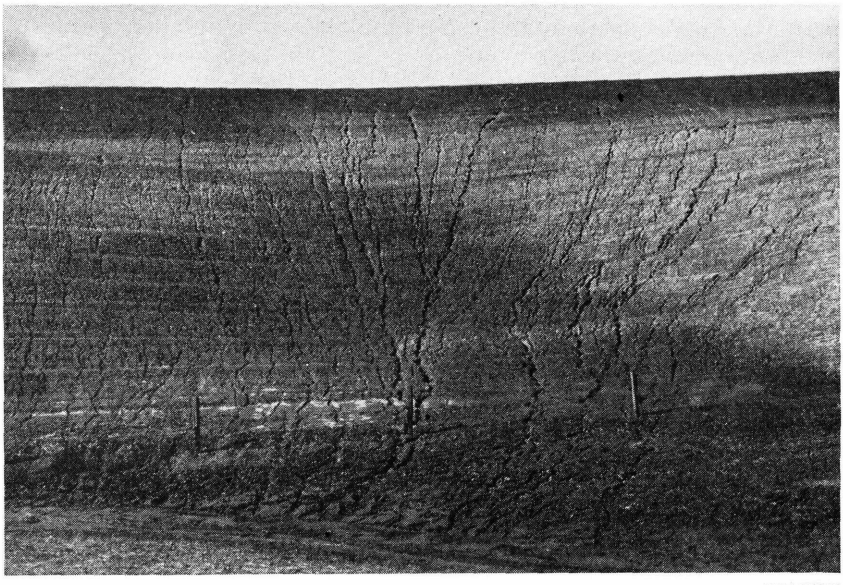
Another means of protecting against erosion where crop residues are scanty is to alternate countour strips of fallow and grain each year. On fields strip-cropped in this way the yield is higher than on those having the entire area in a crop one year and fallow the next.

Wind strip cropping is a common practice over large areas of the Plains. More and more the strips are being run on the contour instead of in relation to the direction of the wind, and the fallow strips are being protected by mulch. Mulch farming is not carried out properly unless all cultivation is on the contour.

In the initial tillage the soil should be loosened as deep as it is to be cultivated, for if this depth is finally reached only in successive tillage operations, the loss of moisture through evaporation will be greater. This practice, common to all areas, is especially important where rainfall is low.

IN THE WHEAT-GROWING AREAS WEST OF THE ROCKIES

West of the Rocky Mountains, as in the Great Plains, there are areas where a crop can be grown every year and where there is enough rainfall to produce a crop only every other year. In both areas, the greater part of the annual rainfall comes from October to May. Erosion occurs mainly in the winter and early spring (fig. 5). The summer months are dry and hot, and crop residues therefore decompose slowly.



WN-35321

FIGURE 5.—Erosion on finely worked land caused by rains during February and March. This field was plowed with a moldboard plow. The surface was worked to a fine condition with the harrow and the field was planted to winter wheat.

IDA-25130; WN-40043; WN-40042

FIGURE 6.—Heavy stubble after fall preparatory treatment with a one-way disk (*A*), with an eccentric disk (*B*), and with a rotary subsoiler (*C*). All three of these machines bring the straw in contact with the soil so that it decomposes more rapidly. The small basins made by the eccentric disk catch water; the subsoiler leaves the surface rough and open.

596722°—44——2

SUMMER FALLOW

In summer-fallow areas wheat is the principal crop. Crop residues may in some years be light and in others extremely heavy. If the stubble is heavy, the straw must be broken into shorter lengths and brought into contact with the soil to induce partial decomposition. The stubble must be broken down also to prevent its collecting on the standards of rod weeders or other equipment. This work is done in the fall after the crop is harvested.

Figure 6 shows three fields in which the stubble was broken down: In one, with a one-way disk; in another, with an eccentric disk; and in a third, with a rotary subsoiler. A light disking in the spring levels the furrows, or basins, left by the eccentric disk and breaks down the stubble still further.

If residues are too light, the rotary subsoiler may be used in the fall to loosen the soil and leave depressions for better conservation of rainfall.

The initial tillage is usually done in the spring. It must leave all crop residues above the position at which the rod weeder is operated. The soil should be compacted soon after the initial tillage to prevent circulation of air through the surface layer of soil.

The land may or may not be disked before the initial tillage operations, depending on the condition of the residues, the soil type, and weather conditions. If the land is disked before it is plowed, less cultivation will be required to prepare a good seedbed.

The first cultivation for killing weeds is done with a rod weeder immediately after the initial tillage to establish a line of soil moisture below the mulch. The larger type of weeder should be used on heavy stubble. These newer, larger models have a clearance between the frame and rod of at least 23 inches. The rod will operate through a fair amount of short straw, but long, wet straw will cause the same difficulties experienced when other types of weeders are used.

For winter wheat, all cultivation for preparing the seedbed can be done with the rod weeder. The soil in which the seed is placed must be well prepared, even though the surface remains rough. In some areas seeding is delayed until the first fall rains moisten the soil down to the moisture line established by the tillage operations. If weeding operations are conducted so as to maintain this moisture line near the surface, light rains may put the soil in suitable condition for planting. If the surface has been allowed to dry too deep, the early rains may not be sufficient to permit planting.

If the fallow land is carried through the second winter for spring seeding, the crop residues will be sufficiently decomposed at the time of seeding to cause no difficulty in preparing the seedbed or in seeding. If crop residues are too scanty to protect the field through the winter, cultivating with a subsoiler puts the soil in condition to receive winter rainfall.

ANNUAL CROPPING

A rotation of wheat and a legume is the cropping system recommended for areas of the Pacific Northwest where there is enough rainfall to produce a crop every year. The amount of nitrogen furnished the crop following the legume is determined in part by the

way the legume is used. The stubble from a leguminous crop yields the greatest return when converted into a mulch through which succeeding crops are planted. Experimental work has shown that yields of winter wheat following sweetclover are higher on fields where the sweetclover is used as a mulch than on those where it is plowed under. Higher yields have also been reported for wheat following other legumes used as a mulch.

WN-5114

FIGURE 7.—This field was plowed in the fall with a large one-way disk. The stubble has sufficiently decayed to permit seeding of peas without difficulty.

In the year when a legume follows wheat, adequate protection of the land through the winter and spring is not difficult. The wheat stubble is plowed in the fall with either a modified moldboard plow or a large one-way disk. This plowing loosens the soil to the desired depth, brings the stubble into contact with the soil or partially covers it (fig. 7), and reduces loss of soil and water. By spring the straw will be sufficiently decomposed to offer no obstacle to the preparation of the seedbed for the legume.

In years when the legume is used as a mulch for the wheat, the method of tilling the land depends on whether the legume is sweetclover, alfalfa, or peas. Pea straw is usually too scanty to give adequate protection, whereas sweetclover or alfalfa must not be allowed to grow more than 2 feet before it is plowed or the residue will be too heavy to permit cultivation for wheat seeding.

In the wheat and pea rotation it is difficult to protect the land the year after it is in peas, especially if winter wheat is planted. The residues from peas are not so heavy as those from wheat, and they decompose more rapidly because they have a higher nitrogen content. If winter wheat follows peas, it is imperative to scatter the pea straw at harvest and seed the wheat with the least possible destruction of

the straw. The wheat may sometimes be seeded through the pea straw without any preparation of the seedbed if disk drills are used in planting. Under other conditions a light disking may be required to loosen the soil before the seed is planted. Seeding should always be on the contour.

Planting spring wheat after peas instead of winter wheat makes control of erosion easier, because rough tillage in the fall, in addition to whatever organic mulch there is, will protect the pea land during the critical erosion period of winter and early spring. The grain is seeded after the time of greatest danger from erosion has passed, and good farming practices will then give sufficient control of erosion.

IN THE SOUTH AND EAST

The experiences of farmers in the Pacific Northwest and on the Great Plains has proved that using crop residues and other organic materials as a mulch is a practice that can well be made a part of conservation farming. In the East and South less extensive use has been made of material grown on the land to be mulched. But this practice will doubtless become more widespread in these areas. Machinery suitable for cultivating row crops through crop residues is coming into use. Cover or green manure crops are more and more being used as mulch. Terraced fields mulched with crop residues require less frequent maintenance operations.

COVER CROPS AS MULCH

All or most of the top growth of cover crops can be left on the surface by tillage methods similar to those employed for producing a stubble mulch. The initial tillage of a cover crop should destroy the

CAL-5349

FIGURE 8.—Light disking of an annual cover crop. This operation leaves most of the organic material on the surface and roughens and loosens the soil.

growth to prevent moisture losses through transpiration and to produce the mulch. Thereafter the only cultivation required is that to control weed growth and prepare a seedbed for the crop that follows. Cover crops can be cut down for a mulch on cultivated fields or in orchards (fig. 8).

ROW CROP AND LEGUME ROTATIONS

If legumes are used in rotation with row crops the roots of the legumes should be severed with a sharp share-type implement that loosens the soil sufficiently to insure killing the legume. The row crop can be planted through the legume mulch, much as through grain stubble. Planting a row crop through a mulch is less difficult than seeding small grain. Figure 9 shows sorghum following a small-grain crop, the residues of which were used as a mulch.

If land to be seeded to a row crop has been in a grass or a legume for some time, the heavy, tough sod should probably be broken by the method ordinarily employed, and the legume that follows the row crop in rotation can be cultivated to make a mulch for the crop that follows it.

The residue from a row crop may be used to mulch the land the year it is to be planted to a legume. If the row crop is corn, the stalks must be cut with a stalk cutter (fig. 10) and very likely disked. Under some conditions special shredders or cutters may be needed. The residue must be distributed evenly over the field. Tillage operations are done with much the same type of implements used in the cultivation of row crops. Grain drills and row-crop planters suitable for seeding are described on pages 21–22.

C-8182

FIGURE 9.—Sorghum following a small-grain crop. Tillage operations left the ground well protected by a mulch. The field has received two cultivations.

C-8254

FIGURE 10.—Cutting stalks with a two-row cutter before initial tillage of the field.

TILLAGE IMPLEMENTS

MODIFIED MOLDBOARD PLOWS

A plow from which the moldboard has been removed lifts and breaks the soil instead of turning it over and leaves most of the crop residue on the surface.

A moldboard plow can be modified for mulch tillage simply by removing the moldboard, if the share is bolted on (fig. 11). If the share is "quick-detachable" and the moldboard is removed, it is necessary to attach the share and brace the plow bottom by bolting a strap of steel as thick as the top of the share to the lower row of holes used in fastening the moldboard (fig. 12). Scrap steel, such as old drill tires, is satisfactory for the brace.

If the regular plow bottom is removed, duckfoot shovels may be attached to the plow frame. These shovels may be made from discarded equipment (fig. 13). Lister shares (fig. 14) also may be attached to plow frames by means of specially constructed frogs.

Removal of the moldboard decreases the draft sufficiently to permit an increase in the width of the area tilled without an increase in the power unit. Changes in wheel adjustment must often be made to compensate for the elimination of the furrow.

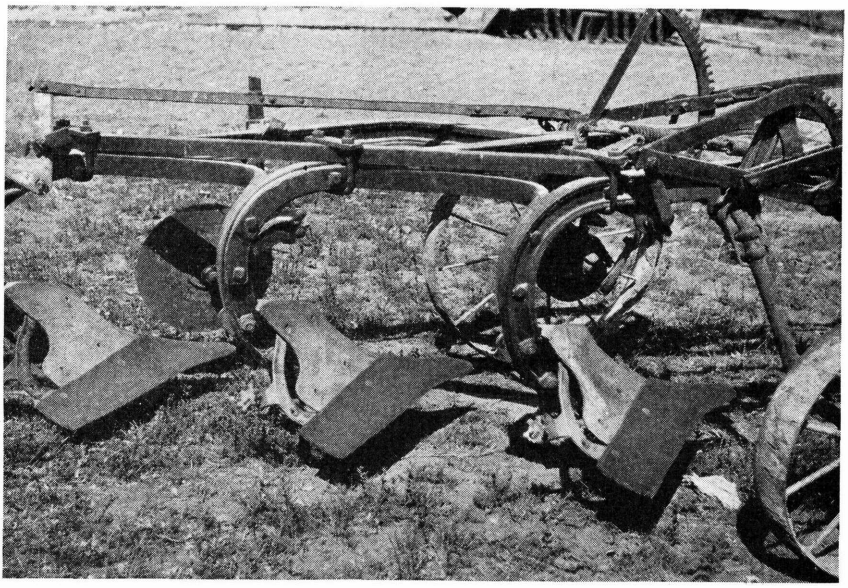


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FIGURE 11.—A moldboard plow of the bolted-share type from which the moldboard has been removed. This plow can be used as it is or the frog may be protected by a steel strap.

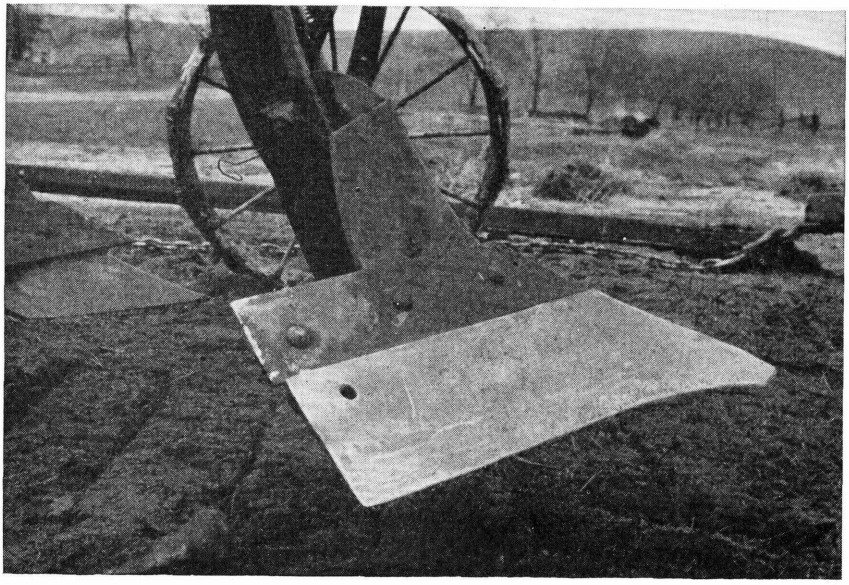

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FIGURE 12.—The moldboard has been removed, and the "quick-detachable" share is fastened to the plow and supported by a 3-inch strap.

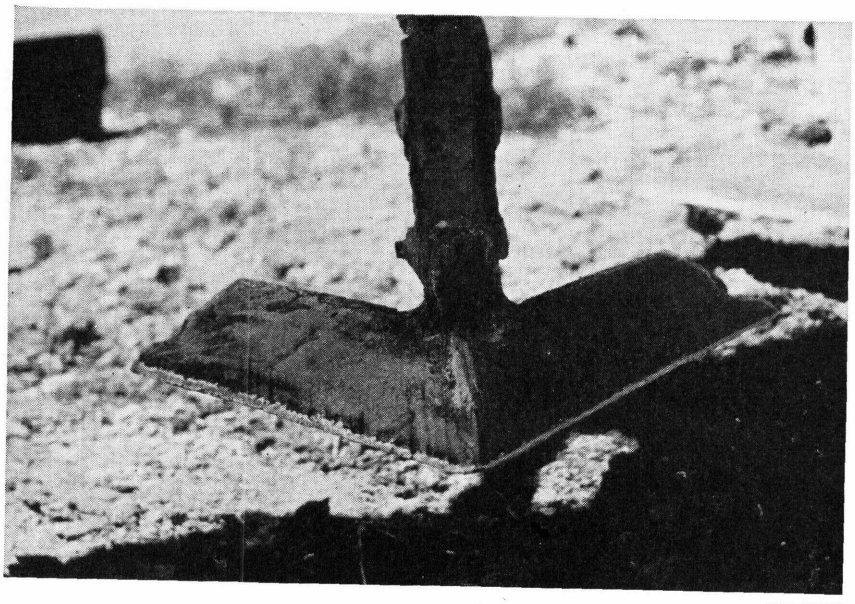

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FIGURE 13.—A duckfoot shovel constructed from discarded road-grader blade and attached to a moldboard plow frame. Similar shovels may be made from old plow shares.

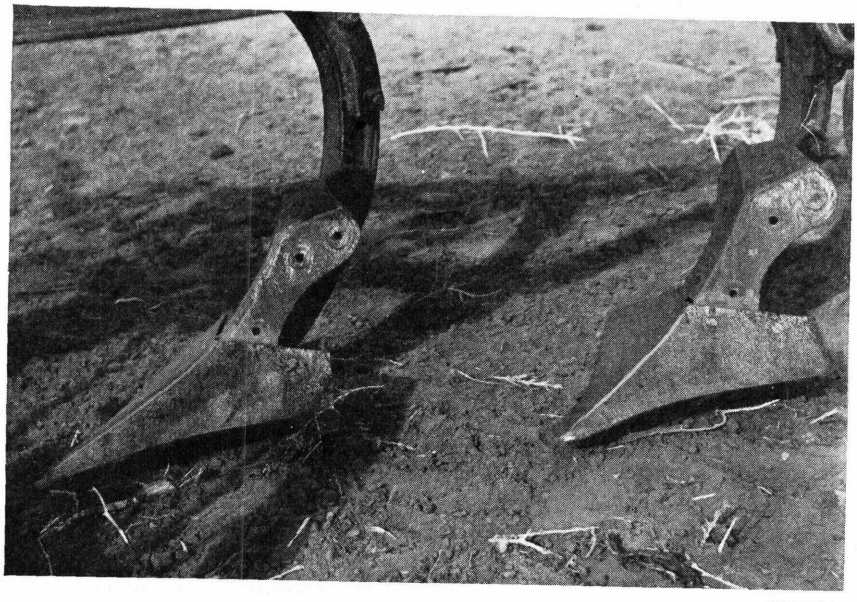

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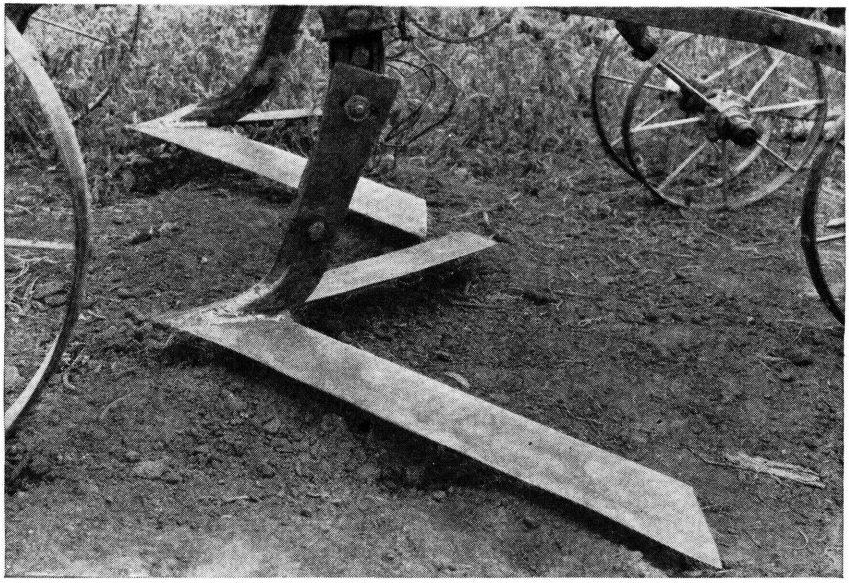
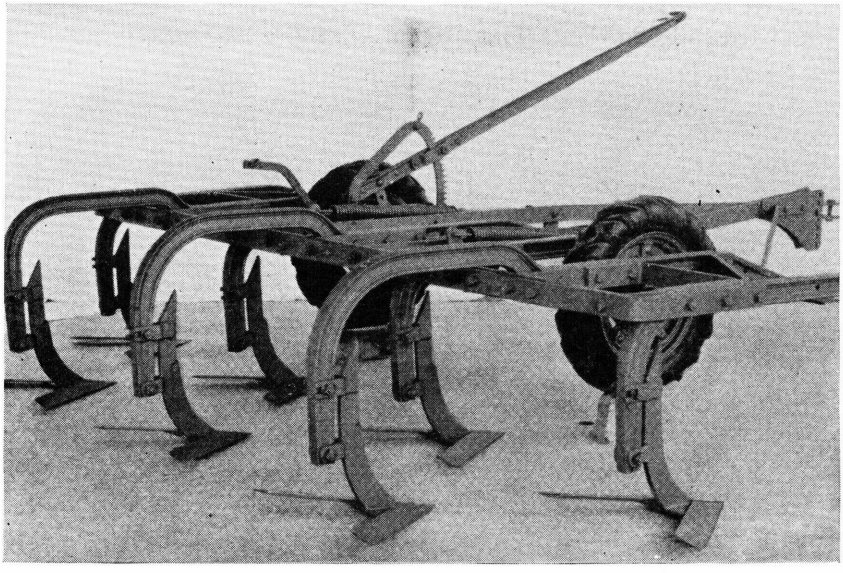
FIGURE 14.—Lister shares attached to a plow frame by specially constructed frogs.



C-8184

FIGURE 15.—Large sweeps attached to a two-row lister frame convert this implement into one that can be used in mulch farming.



WN-3541

FIGURE 16.—One type of commercial machine, with 24-inch sweeps. Rolling coulters may be placed ahead of the sweeps.

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DUCKFOOT SHOVELS OR SWEEPS

Standard duckfoot shovels or sweeps may be attached to plow, cultivator, and lister frames (fig. 15), to tool-bar machines, or to machines constructed especially for their use. On these special machines the frames are higher, the standards farther apart, and the shovels larger and longer than those of the standard-cultivator type.

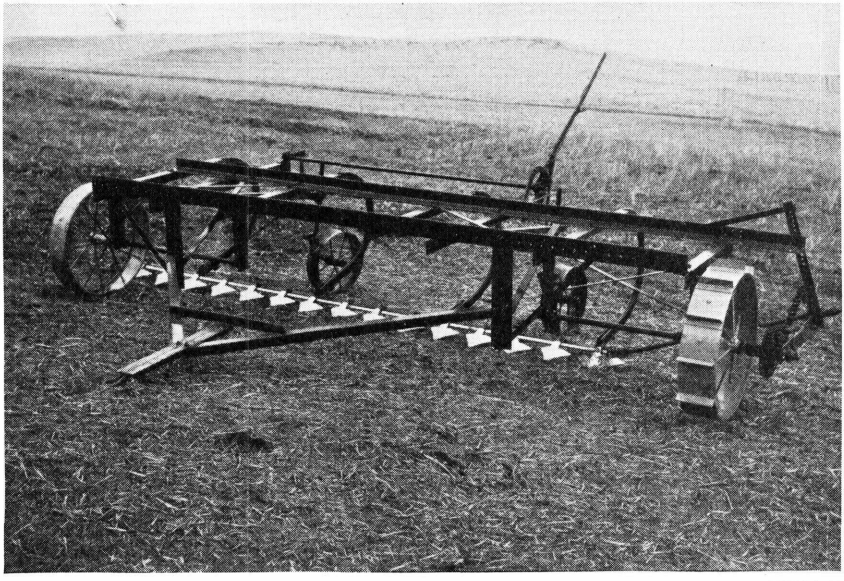
In most commercial machines the large duckfoot shovels or sweeps are arranged in two rows (fig. 16) to permit underspacing between the units. This spacing facilitates the passage of crop residues between the beams or units. A rolling coulter may be attached to each beam just ahead of the sweep to cut through heavy crop residues.

Duckfoot shovels or sweeps operate parallel to the ground surface. They leave the stubble in an upright position, best for collecting and holding snow. These implements, both the home-made and the commercial, are widely used for initial tillage and cultivation of fallow in the Great Plains.

ROTARY ROD WEEDERS

A rotary rod weeder consists of a rod mounted in a frame and provided with a driving mechanism that rotates the rod opposite to the direction of the drive wheels. The most satisfactory weeder used in cultivating through crop residues has a $\frac{7}{8}$-inch square rod, which operates at a depth of 2 to 4 inches. It kills weeds, lifts clods and trash to the surface, and compacts the soil below the rod.

This regular rod equipment may be removed from the weeder and replaced by a heavy bar equipped with points or shovels that penetrate hard soil (fig. 17). This attachment has a rotating rod back of



WN-35416

FIGURE 17.—A rod weeder equipped with shovel attachment. Other types of shovels, or points, are employed on some machines.

the shovels to prevent collection of trash on the bar supporting the shovels.

The regular rod weeder operates best in loose to moderately loose soil. If the rod weeder or summer rains compact the soil so that operation of the weeder is not satisfactory, the shovel attachment should be brought into use. One cultivation with this attachment loosens the soil as much as does the disk or cultivator.

On some ranches in the West where soils are light, all tillage operations in growing wheat are carried out with a rod weeder and the shovel attachment. The initial tillage is with the shovel attachment, the weeding with the regular rod equipment. Land cultivated with the rod weeder seldom needs other preparation for fall seeding. Using the rod weeder as described here makes the purchase of several tillage machines unnecessary.

The light draft of this equipment enables tilling to the same depth with the same power unit a strip about twice as wide as that covered with the moldboard plow or disk tiller. The tillage cost, therefore, is much less than that for other equipment.

STRAIGHT-BLADE CULTIVATORS

A straight-blade cultivator consists of a straight blade of steel attached to a frame constructed to permit regulation of the depth at which the blade operates.

These machines are made with lightweight frames and light blades or heavyweight frames and heavy blades. Blades may be tilted so that the back is higher than the cutting edge as the blade is drawn through the soil. Curved blades also are used, particularly on the

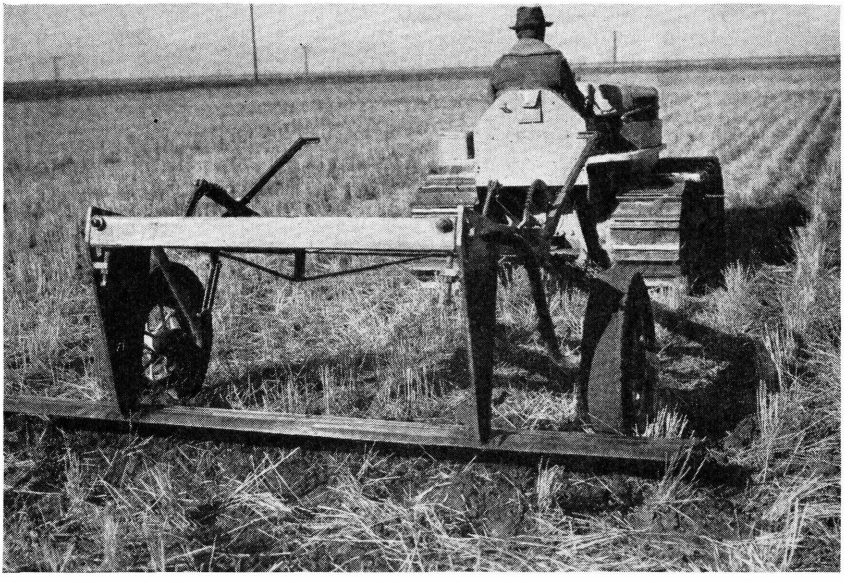


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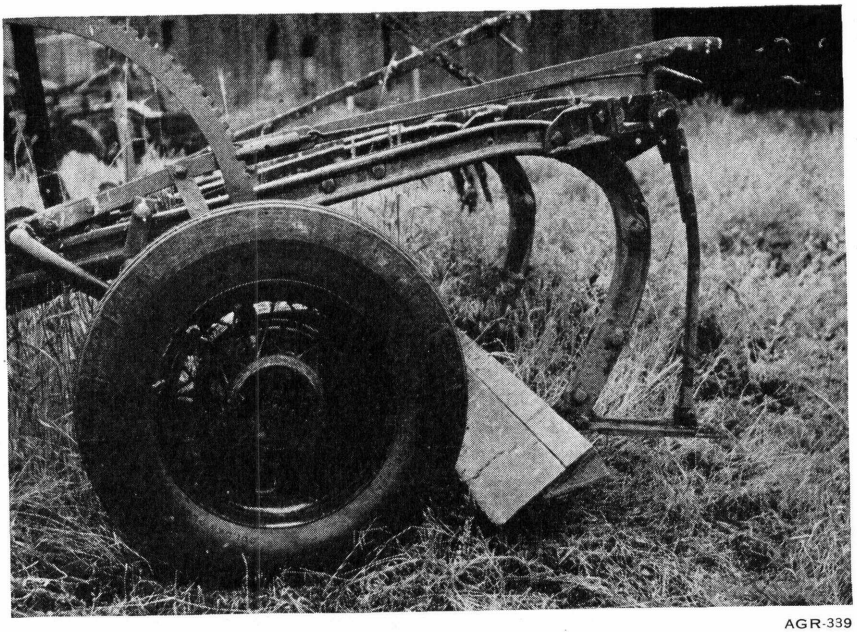
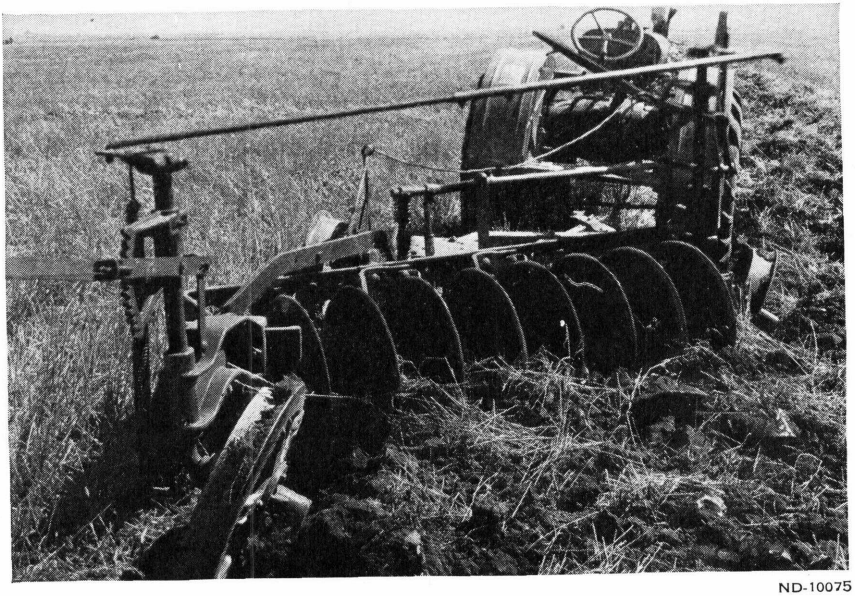
FIGURE 18.—This machine is equipped with a heavy curved blade that raises the soil, roughens the surface, and leaves crop residue on top.



AGR-339

FIGURE 19.—A farmer made this straight-blade cultivator by mounting a discarded road-grader blade on a plow frame.



ND-10075

FIGURE 20.—A 26-inch one-way disk.

heavy machines. These blades lift the soil somewhat as they advance. The heavy machines are sufficiently strong to be used as substitutes for plows (fig. 18); the light blades are used mainly as cultivators.

Stragiht-blade implements may be made by attaching road-grader where a smooth surface and stubble in an upright position give the best protection to the soil. As the blade operates 3 to 6 inches below the surface it can be adjusted to sever weed roots, control bindweed, and till fields of grain stubble.

Straight-blade implements may be made by attaching road-grader blades to plow frames (fig. 19).

DISKS

On grain fields, disks may be used for breaking down the stubble, for initial tillage, or for preparing seedbeds. Both one-way and eccentric disks are used for this purpose.

In selecting one-way disks, choose the size needed for the job. The 22-inch and the 26-inch disks are most widely used.

The 22-inch disk, with the disks 8 inches apart, is best adapted to light soils and small quantities of crop residues. The 26-inch disk (fig. 20), with the disks 10 inches apart, is better on hard ground and heavy stubble. It is used on heavy-textured, dry soils to produce a rough, cloddy surface. On light soils it may turn under the residues as completely as the moldboard plow.

One-way disks cannot be operated without some coverage of residues, but if properly adjusted and operated at correct speed they leave sufficient residues on top. The faster operation gives the greater coverage of residues and pulverization of soil.

The one-way disk is also called the one-way, the disk tiller, harrow plow, the gold digger, and the wheatland plow.

The eccentric disk differs from the one-way in that on the individual disks the holes for the shaft are a short distance off center. The movement of the disks, therefore, digs up the soil and throws it away from the disks so as to leave basins on the field. These basins hold rainfall and thus reduce runoff.

Cultivation with the eccentric disk brings stubble into contact with the soil and so induces decay. Where stubble is heavy, therefore, this disk may be used to reduce the amount of stubble on the surface of the field.

On certain makes of equipment eccentric disks are interchangeable with regular disks.

SUBSOILERS

The point- or shovel-type subsoiler and the rotary subsoiler are used for subsoiling. The point-type subsoiler has not proved very successful and has largely been discarded. The rotary type is more effective in getting water into the soil. Point- or shovel-type subsoilers may be either home-made or built on specially constructed frames suitable for operation with tractor power. The home-made equipment is constructed by removing the moldboard plow bottoms and attaching points extending 12 inches beyond the beams. These points may be made from discarded plow beams. The practice has been to run this

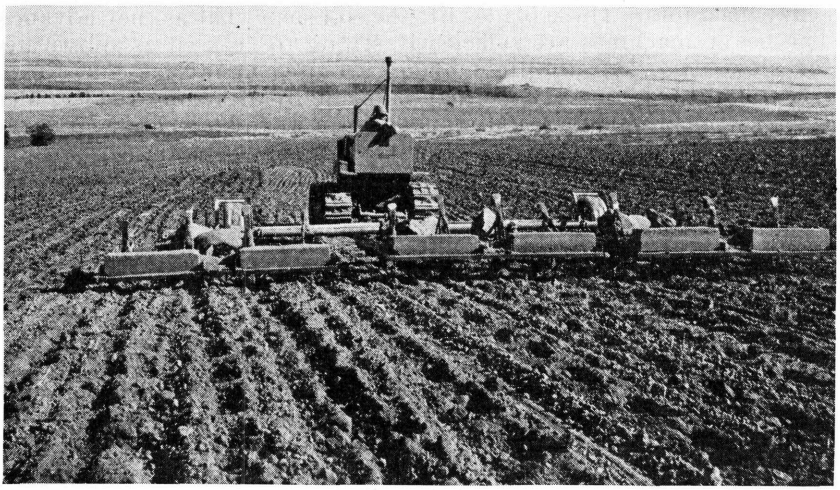


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FIGURE 21.—A rotary subsoiler loosens the soil and leaves surface pockets on this summer-fallowed field, which is to be planted to a spring crop. This tillage will partly compensate for lack of stubble.

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FIGURE 22.—One type of rotary subsoiler used in the fall to prevent loss of water from frozen ground and to break down heavy stubble.

machine at intervals of 5 to 6 feet on the contour and to loosen the soil to a depth of 12 to 14 inches. This work is done in the stubble after harvest or before the rainy season.

The operating part of a rotary subsoiler is a cylinder mounted in a frame suitable for tractor operation. On the cylinder are teeth or points that penetrate the soil to a depth of 10 to 12 inches at intervals of approximately 2 feet.

The rotary subsoiler loosens the soil and leaves pockets that hold winter rainfall. It is used on fallow that is to be carried over the winter for spring planting, especially if crop residues are scanty (fig. 21). It is also useful on fields where the stubble is heavy (fig. 22) for it breaks down the stubble and pushes part of it below the surface. It can also be run over a field shortly after it has been seeded to winter wheat. This treatment allows more water to enter the soil but does not reduce the stand of wheat sufficiently to affect it.

Since the draft of this implement is light, it can be operated at relatively low cost.

GRAIN DRILLS

Seeding grain through a stubble mulch requires the use of furrow openers that cut through bunches of straw so that the seed may be deposited in the soil. Both disk- and shovel-type furrow openers are in use.

The seed may be brought into contact with the soil and a much better stand obtained by using press-wheel drills. On sloping land it is necessary to employ a drill that has the press wheels built into the frame of the drill. The drills that seed in rows 10 inches apart are known as semideep furrow drills, and those that seed in rows 12 or 14 inches apart are known as deep-furrow drills.

The semideep furrow drill is most used in summer-fallow areas on level or gently sloping land. The 10-inch spacing of furrows allows clods and trash to be thrown into ridges between the furrows.

The furrow openers may be placed in two rows, one 20 inches in front of the other. In each row the furrow openers are 20 inches

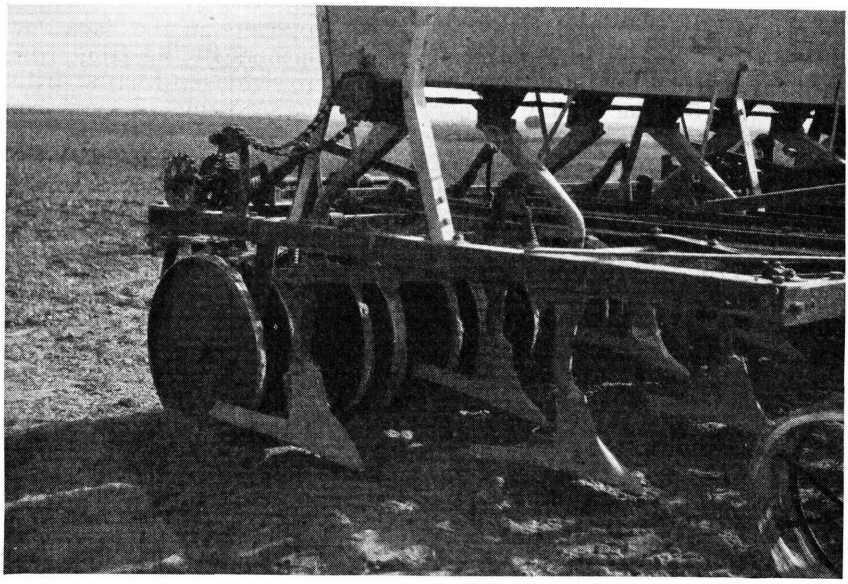

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FIGURE 23.—Shovel-type furrow opener on deep-furrow drill. Extra wings have been welded on the shovels to secure cultivation of soil for weed control at seeding time.

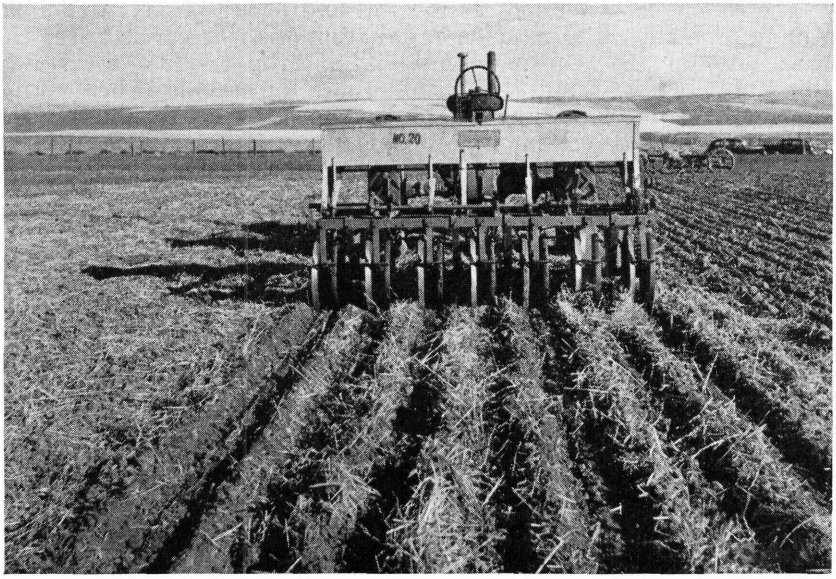

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FIGURE 24.—Seeding with shovel-type deep-furrow drill. Seed is placed in the bottom of the furrow. Loose soil and trash is thrown into ridges between the furrows.

apart and in the two rows they are staggered so that the furrows in which the seed is planted are 10 inches apart. If these furrows are less than 10 inches apart, the furrow openers in the back row throw soil into the furrows made by the openers in the front row.

Some farmers have converted hoe drills into semideep-furrow drills by rearranging the furrow openers and attaching wings of sheet iron for ridging the soil between the rows.

The deep-furrow drill spaces the grain rows at either 12 or 14 inches. On this drill the disk-type furrow openers are placed in one row, the shovel-type openers in two rows (fig. 23). The wide spacing permits the movement of a large amount of loose soil and trash from the area in which the seed is placed (fig. 24). The removal of this soil permits placing the seed in moist soil without its being covered too deep. The ridges afford protection to young grain against wind and retain snow or rain.

ROW-CROP PLANTERS

By slight modifications grain drills can be made suitable for planting row crops through a stubble mulch. Disk- or shovel-type furrow openers may be attached to standard grain drills and used for row-crop planting by stopping enough of the holes to give the desired spacing of the rows. It may be necessary to change the design of the furrow openers to give a more desirable ratio between the depth of furrow and the area cleared of mulch.

The addition of a coulter, or jointer, to cut or move the trash may be all that is required for some types and quantities of residue.

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